1919

# Aluminium

Joseph William Richards

# ALUMINIUM

By J. W. Richards

The year 1918 was a disturbed and irregular year for aluminium. It is estimated that 90 per cent. of the total production was turned from the uses of peace to the purposes of war. In tonnage produced, aluminium now stands fourth among the non-ferrous metals, being exceeded only by copper, zinc and lead. It surpasses tin, now, by a good margin, and will undoubtedly overtake lead and zinc in the course of time; let us hazard the guess that lead will be overtaken by 1930 and zinc by 1940. In variety of uses, and importance of its functions, it is probably true at the present time that aluminium is surpassed only by iron and copper. The dreams of Henri St. Claire Deville are coming true.

Aluminium did not escape the attention of government price regulators in 1918. The demand outside of government contracts was so far from being met by the supply that its price would have soared, much to the detriment of the industry in general, if it had not been fixed. Early in 1918 the price was in France 6.40 francs per kilo, or 58 cts. per lb.; later in the year it was fixed by the French Government at 4.80 francs, or 43.5 cts. per pound. In England it was fixed at £150 per ton (33 cts. per pound). In the United States the price-fixing committee of the War Industries Board agreed with the producers on 33 cts. per lb. on lots of 50 tons or over, for 98–99 per cent. ingot metal, which agreement was approved by the President. This price was made effective from June 1, 1918, to Mar. 1, 1919. The conditions imposed by the Government on the producers were as follows:[1] "First, the producers of aluminium will not reduce the wages now being paid; second, aluminium shall be sold to the U. S. Government, to the public in the United States and to the Allied governments at the same maximum base price; third, the producers will take the necessary measures under the direction of the War Industries Board for the distribution of aluminium to prevent it from falling into the hands of speculators who might increase the price to the public; and, fourth, they will pledge themselves to exert every effort necessary to keep up production so as to insure an adequate supply during the war."

Under these conditions of government supervision and control, immense quantities of aluminium were put to military uses. It has been estimated[2] that the Allies put 90,000 metric tons of it into airplanes alone in 1918, while the Central Empires probably put 15,000 tons to the same use, which was all the output at their disposal. The *Engineering*

[1] *Eng. Min. Jour.*, June 8, 1918.

[2] *Jour. du Four Electrique.*

*and Mining Journal*[1] summarizes such military uses, aside from explosives and illuminating shells, as follows:

"Substantially one-third of the weight of the Liberty motor was composed of aluminium, used wherever possible, for engine-beds, crank-cases, pistons, oil-pumps, camshaft-housings, etc. Forty separate parts of the Liberty motor alone were of aluminium. It was also used for the gasoline tanks, fuselage, hoods, cowling, seat backs, and aileron frames; in wireless telegraph and telephone, barometer cases, camera parts and in range finders. Observation balloons have the exterior painted with aluminium paint, its reflecting power reducing changes of temperature in the interior. Other uses are mess equipment for the soldier, water bottle, identification tag, and parts of gas masks."

Under the circumstances, the greatest possible production from existing plants was secured, in order to meet the necessities of the military and to keep the users of aluminium in civil industries partly supplied. What will happen to the industry now that the war has ceased is one of the great metallurgical questions of the hour. A British editor (*The Mining Journal*) sees relief in the great demand which must arise from ordinary industries, whose activities have been so greatly limited during the war, and particularly from new hydroelectric installations requiring large quantities of long-distance transmission line. In the writer's opinion, if the production is largely in excess of the demand, which is questionable, a lowering of price to approximate a small but fair profit above cost price would bring to the producers all the demand they could possibly handle—perhaps far more. The days of selling at 100-per cent. profit should be regarded as past, and any complaint of lack of demand can be quite properly answered by the suggestion of reasonable reductions in the selling price.

IMPORTS OF ALUMINIUM INTO THE UNITED STATES 1913–1918
(By fiscal years ending June 30)

| Country from Which Exported. | 1913. Pounds. | 1914. Pounds. | 1915. Pounds. | 1916. Pounds. | 1917. Pounds. | 1918. Pounds. |
|---|---|---|---|---|---|---|
| Austria-Hungary | 1,041,030 | 1,300,717 | 264,552 | *Nil.* | *Nil.* | *Nil.* |
| Belgium | 834,928 | 227,563 | 194,708 | *Nil.* | *Nil.* | *Nil.* |
| France | 2,580,447 | 2,081,468 | 1,798,127 | *Nil.* | *Nil.* | *Nil.* |
| Germany | 8,314,908 | 1,632,226 | 11,133 | *Nil.* | *Nil.* | *Nil.* |
| Italy | 720,992 | 8,816 | *Nil.* | *Nil.* | *Nil.* | *Nil.* |
| Netherlands | 482,122 | *Nil.* | *Nil.* | *Nil.* | *Nil.* | *Nil.* |
| Norway | 380,800 | 1,173,800 | 2,046,168 | *Nil.* | *Nil.* | *Nil.* |
| Portugal | *Nil.* | *Nil.* | 4,321 | *Nil.* | *Nil.* | *Nil.* |
| Switzerland | 1,058,208 | 2,612,747 | 264,552 | *Nil.* | *Nil.* | *Nil.* |
| United Kingdom | 4,822,180 | 2,110,257 | 1,675,616 | 21,876 | 120 | *Nil.* |
| Canada | 6,722,401 | 4,816,067 | 7,499,313 | 8,148,309 | 1,879,859 | 1,498,255 |
| Mexico | *Nil.* | *Nil.* | *Nil.* | 1,521 | 11,792 | 220 |
| Central America | *Nil.* | *Nil.* | *Nil.* | 528 | 955 | 78 |
| West Indies | 338 | 381 | 150 | 2,043 | 6,655 | 4,949 |
| South America | *Nil.* | *Nil.* | 6,532 | 26,251 | 4,619 | *Nil.* |
| Other Countries | *Nil.* | *Nil.* | *Nil.* | *Nil.* | *Nil.* | 274 |
| Total | 26,958,354 | 15,964,042 | 13,765,172 | 8,200,528 | 1,904,000 | 1,503,776 |

[1] Feb. 1, 1919.

PRODUCTION, IMPORTS AND VISIBLE SUPPLY OF ALUMINIUM IN THE UNITED STATES

| | Production. | | | Imports. | | | Exports. | Visible Supply. (*b*) |
|---|---|---|---|---|---|---|---|---|
| | | | | Crude. | | Mfrs. | | |
| | Pounds. | Value. | Per Pound. | Pounds. | Value. | Value. | Value. | Pounds. |
| 1903 | 7,500,000 | $2,325,000 | $0.31 | 498,655 | $139,298 | $4,273 | $157,187 | 8,000,000 |
| 1904 | 7,700,000 | 2,233,000 | 0.29 | 515,416 | 128,350 | 478 | 166,876 | 8,216,000 |
| 1905 | 11,350,000 | 3,632,000 | 0.32 | 530,429 | 106,108 | 33 | 290,777 | 11,880,000 |
| 1906 | 14,350,000 | 5,166,000 | 0.36 | 770,713 | 154,292 | 1,866 | 364,251 | 15,121,000 |
| 1907 | 26,000,000 | 10,920,000 | 0.42 | 872,474 | 181,351 | 1,124 | 304,938 | 26,872,000 |
| 1908 | 13,000,000 | 4,095,000 | 0.315 | 465,317 | 80,268 | 2,334 | 330,092 | 13,465,000 |
| 1909 | 15,000,000 | 3,345,000 | 0.223 | 5,109,843 | 745,963 | 12,878 | 567,375 | 20,110,000 |
| 1910 | 12,000,000 | 2,736,000 | 0.228 | 12,271,277 | 1,844,830 | .......... | 949,215 | 24,271,000 |
| 1911 | (*e*)28,600,000 | 5,720,000 | 0.20 | (*d*)4,173,308 | 598,272 | (*d*)63,899 | 1,158,603 | 32,773,000 |
| 1912 | (*e*)40,000,000 | 9,200,000 | 0.23 | 22,759,937 | 3,092,889 | 428,182 | 1,347,621 | 62,760,000 |
| 1913 | (*e*)64,900,000 | 13,600,000 | 0.21 | 23,185,755 | 3,905,977 | 1,090,229 | 966,094 | 88,086,000 |
| 1914 | (*e*)90,000,000 | 16,740,000 | 0.186 | 16,241,340 | 2,729,383 | 1,308,036 | 1,546,510 | 106,241,000 |
| 1915 | (*e*)99,000,000 | 31,581,000 | 0.319 | 8,534,834 | 1,511,988 | 301,863 | 3,682,117 | 107,535,000 |
| 1916 | (*e*)139,000,000 | 47,260,000 | 0.34 | 6,646,385 | 1,729,298 | 55,864 | 15,419,134 | 145,646,000 |
| 1917 | (*e*)200,000,000 | 74,000,000 | 0.37 | 58,703 | 18,084 | 57,461 | 14,586,467 | (*f*)200,059,000 |
| 1918 | (*e*)225,000,000 | 74,250,000 | 0.33 | 1,800,436 | 569,150 | 39,114 | 10,869,388 | 226,800,000 |

(*a*) Not reported. (*b*) Production plus imports. (*d*) From July 1 only. (*e*) Estimated. (*f*) Included 9,470,206 lb. of ingot metal and alloys, and 550,198 lb. of plates and sheets, valued at $4,571,193, during the last half of the year.

Statistics are still almost impossible to get. It is a standing discredit to the larger producers of aluminium that either for purposes of deceiving each other, or hood-winking the governments they work under, or misleading the public, they refuse to state publicly the true extent of their business. Such a policy, pursued steadily for several years, has alienated from them the sympathy of the public and legislators when these companies ask for governmental favors, and has thus cost them in real money far more than they could possibly have lost by a proper policy of non-concealment. The aluminium industry should be conducted as openly and fairly as the steel or the copper industry, and the public has a clear right to know the real facts—particularly when favors regarding price-fixing, tariff adjustments, water-power concessions, etc., are being asked from the people's representatives in the government.

Using the best information to be had, we estimate the production of 1918 as follows:

| | Pounds. | Metric Tons. |
|---|---|---|
| United States | 225,000,000 | 102,000 |
| Canada | 33,000,000 | 15,000 |
| France | 48,400,000 | 22,000 |
| Switzerland | 33,000,000 | 15,000 |
| Austria | 17,600,000 | 8,000 |
| Italy | 17,600,000 | 8,000 |
| Great Britain | 30,800,000 | 14,000 |
| Norway | 39,600,000 | 18,000 |
| Germany | 44,000,000 | 20,000 |
| | 489,000,000 | 222,000 |

Distributing this production by the firms engaged in the business, we have:

| | Metric Tons. |
|---|---|
| Aluminum Company of America<br>Northern Aluminum Co. of Canada | 117,000 |
| British Aluminium Co. (Great Britain and Norway) | 19,000 |
| The Aluminium Corporation, Limited | 3,000 |
| L'Aluminium Francaise (France and Norway) | 32,000 |
| Aluminium Industrie Aktien Gesellschaft (Switzerland and Austria) | 23,000 |
| Hoyang Falden Norsk Aluminium (Norway) | ...... |
| L'Aluminio Italiano (Italy) | 8,000 |
| German Government Works | 20,000 |
| | 222,000 |

ESTIMATED WORLD'S PRODUCTION OF ALUMINIUM
(In metric tons)

| Year. | Austria. | Canada. | France. | Germany. | Great Britain. | Italy. | Norway. | Switzerland. | United States. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1913 | 5,000 | 5,916 | 15,000 | ......... | 10,000 | (a) 874 | 2,500 | 10,000 | 29,500 | 78,790 |
| 1914 | 4,000 | 6,820 | 12,000 | ......... | 8,000 | (a) 937 | 2,500 | 10,000 | 40,600 | 84,857 |
| 1915 | 2,500 | 8,490 | 7,500 | ......... | 6,000 | (a) 904 | 3,500 | 12,500 | 45,000 | 86,394 |
| 1916 | 5,000 | 8,500 | 20,000 | ......... | 4,000 | (a)1,126 | 16,000 | 15,000 | 63,000 | 112,626 |
| 1917 | 5,000 | 11,800 | 20,000 | ......... | 6,000 | (a)1,740 | 18,000 | 15,000 | 90,700 | 170,740 |
| 1918 | 8,000 | 15,000 | 22,000 | 20,000 | 14,000 | 8,000 | 18,000 | 15,000 | 102,000 | 222,000 |

(a) Official statistics.

UNITED STATES PRODUCTION AND IMPORTS OF ALUMINIUM SALTS
(In short tons)

| Years. | Production. | | | | | | Imports. (a) | |
|---|---|---|---|---|---|---|---|---|
| | Alum. | | | Aluminium Sulphate. | | | Quantity. | Value. |
| | Quantity. | Value. | Per ton. | Quantity. | Value. | Per ton. | | |
| 1910 | 9,090 | $300,763 | $33.09 | 126,792 | $2,447,552 | $19.30 | 2,127 | $53,671 |
| 1911 | 10,468 | 329,686 | 31.49 | 134,077 | 2,743,336 | 20.46 | 2,283 | 56,833 |
| 1912 | 9,246 | 293,995 | 31.80 | 150,427 | 2,909,495 | 19.34 | 3,342 | 84,606 |
| 1913 | 9,605 | 312,822 | 32.57 | 157,749 | 2,977,708 | 18.88 | 2,702 | 66,549 |
| 1914 | 18,238 | 565,989 | 31.03 | 164,954 | 2,942,572 | 17.84 | 2,891 | 73,028 |
| 1915 | 24,915 | 699,256 | 28.07 | 169,153 | 3,224,495 | 19.06 | 1,408 | 34,320 |
| 1916 | 27,257 | 1,177,881 | 43.21 | 153,860 | 4,410,741 | 28.67 | 1,247 | 68,660 |
| 1917 | 19,714 | 1,017,083 | 51.60 | 178,738 | 5,746,472 | 32.15 | 507 | 39,088 |
| 1918 | ........ | ......... | ....... | ......... | ........... | ........ | 233 | 16,635 |

(a) Includes alumina, aluminium hydrate, or refined bauxite, alum, alum cake, aluminium sulphate, aluminous cake, and alum in crystals or ground.

*United States.*—All the plants of the Aluminum Co. of America, the sole producer, were run to full capacity the whole year. The Canadian Government agreed to permit an ice dam to be built across the south branch of the St. Lawrence River, near the inlet to the power canal which terminates at Massena, N. Y. It is estimated that this ensured an addition of 20,000 hp. to the plant's usual power supply during the winter months, and increased the annual output of aluminium some 3000 tons. There was no change in the plants at Niagara Falls; the Power Commission continued them in full operation because of being on war supplies. The southern plant at Maryville, Tenn., worked at capacity all year;

the plant at Badin was in full operation from June. The great development on the Little Tennessee River is still in course of construction, the dam at Cheoah being 75 per cent. completed; it is expected that power from this power station will be transmitted to Maryville in 1919, and a larger number of reduction buildings are being erected there to utilize it.

Rumors were rife of new companies entering the aluminium business, one to utilize the alumina from the Marysvale, Utah, alunite deposits, another to operate a new process at Niagara Falls, but nothing came of either.

The *Metal Bulletin* (London) estimates the 1918 production at 250,-000,000 lb.; we regard this as probably too high. The United States Geological Survey reports the *value* of the 1918 production as $41,159,-225; we regard this as too low, unless by *value* is meant the cost to the manufacturers and not the average selling price or the average cost to the consumer.

*Canada.*—Nothing new transpired during the year other than the use of all the power available at Shawinigan to turn out a maximum output.

*France.*—We have not been able to get detailed information concerning the French works. They were presumably all working to full capacity, at least until the armistice was declared in November. The Norwegian works of the Aluminium Francaise were run intermittently, being troubled much by labor strikes.

*Great Britain.*—The British Aluminium Co. made profits in 1918 of £420,426, after deducting excess profits taxation. The dividend for the year amounted to 10 per cent. The output in 1918 was "the largest in the company's history," but the amount of it was carefully concealed, even from the stock-holders, and after the ending of the war. Production has been curtailed since the armistice, and large stocks have accumulated because of cessation of Government demand. Arrangements have been made with the Government whereby the large stocks on its hands will be gradually reduced so as not unduly to depress the industry. The great demands which had arisen during the war would certainly lead to a permanently greater application and consumption of aluminium in the near future, which would require further increase of productive capacity.

The Aluminium Corporation, Ltd., of Dolgarrog, North Wales, produces billets, ingots, sheets, granulated and powdered aluminium. They operate bauxite mines at Sillans, Department of Var, France, and refine it to alumina at Hebburn-on-Tyne. Their present hydraulic installation is 9000 kw., but is being largely increased by dams under construction which will give a storage capacity of 1,000,000,000 cubic feet. The output for 1918 is not furnished, but should be, using the power stated, about 3000 metric tons (6,600,000 lb.).

*Norway.*—The operation of some of the works to full capacity was interfered with by labor troubles and shortage of alumina. The works of the Norsk Aluminium at Hoyang is said to be operating only its electrode factory; the rolling and drawing mill is not yet in operation. The production of aluminium by Det Norsk Nitrid at Tyssadal and Arendal was greatly interfered with by strikes. The electrode works at Arendal was started toward the end of the year. Norsk Elektrokemisk is introducing a new process of producing alumina (see further under "BAUXITE"), which is hoped to relieve the shortage and render Norway independent of importations of this basic material. The works of the British Aluminium Co. at Vigeland and Stangfjord ran steadily at their normal capacity.

*Switzerland.*—No reports of the business or profits of the Aluminium Industrie Aktien Gesellschaft during 1918 have come to hand. While exports in 1917 were 11,000 tons, almost all to Germany, the 1918 exports are given as only 7300 tons. Whether this indicated lack of raw materials or simply that Germany was producing most of its own requirements, we do not know. It is reported that several new aluminium works were planned in Austria and Hungary before the war closed; the Austrian were probably extensions controlled by the Swiss company.

*India.*—The high-alumina deposits in India known as laterite have again given rise to rumors of domestic aluminium works. At the suggestion of the Indian Government, Tata, Sons & Co. of Bombay decided to utilize the headwaters of the Koyna River in the Western Ghats, which later joins the Krishna River. A dam is to be built across a valley, producing a lake with an area of 57 sq. mi. and a storage capacity of 132,000,000,000 gallons. A head of 1700 ft. can be utilized, giving 300,000 to 350,000 horsepower. The current would be transmitted to the coast, where factories would be erected at Jaigarh to make aluminium and other electrochemical products.[1]

*Australia.*—The Electrolytic Zinc Co. announces that it will erect at Hobart, Tasmania, aluminium works with an annual capacity of 4000 tons, in order to supply domestic consumption. Other electrochemical plants are projected at the same place.

*Germany.*—The *Echo des Mines* describes some of the developments in producing aluminium in Germany in 1918. Supplies of bauxite, mostly of low grade, were obtained in Dalmatia, Hungary, Hesse, and in the Eifel region near Cologne (volcanic formations). The first works started was at Erftwerk, near Cologne, erected by the Aluminium In-

[1] *Min. Mag.*

dustrie Aktien Gesellschaft of Neuhausen, Switzerland. Electric power for this plant was transmitted at 150,000 volts from steam-turbine power stations at Knap-Sack, near Cologne, and at Reisholz, near Dusseldorf. An electrode factory was built at Erftwerk. The pure alumina was manufactured by the Giulini, Curtius, and Rhenania firms.

Another aluminium plant was erected by the Electrometallurgische Werke Ah. Horrem, near Cologne (supplied with power by the Cologne power station, at 25,000 volts). This is an offshoot of the Griesheim works, which has an alumina plant in Silesia. The Curtius works at Duisburg and the Ichenborf plant are also mentioned as producing aluminium. The Neuhausen company erected an alumina works near Berghien, west of Cologne, with a capacity of 50 to 60 tons of alumina per day, using the poor lignites of this district for fuel. Fifty tons of alumina per day would be 18,000 tons per year, containing over 9000 tons of aluminium. Since the Giulini firm at Mundenheim largely increased its alumina capacity during the war, and the Rhenania firm at Honningen, near Coblenz, as well as the Curtius firm, were producing alumina, it may be inferred that at least 40,000 tons of alumina was produced in Germany in 1918, corresponding to an output of 20,000 tons of aluminium. The immense quantities which they used during the year in airplane construction alone would seem to confirm this estimate.[1]

The Krupp interests were said to have under construction a large aluminium plant in Silesia, which was not completed when the armistice was signed.

## Manufacture

O. Nissen[2] describes manufacturing processes used in Europe. His article contains many mis-statements, such as: "Electrolysis of alumina dissolved in cryolite was well known by Deville and others." Some pertinent facts, however, are given, from which we abstract the following:

Electrodes should not contain more than 1 per cent. of ash. Coal or coke is not pure enough, natural graphite or baked carbon is not pure enough; retort carbon is sufficiently pure. In general, petroleum coke is the best material, its ash content being 0.1 to 0.4 per cent., seldom over 0.5 per cent.

The aluminium pots take 6.5 to 7.5 volts. Thirty to forty are connected in series. The current is usually 8000 to 10,000 amperes; in some cases 15,000 to 20,000. Furnaces are tapped every third or fourth day.

Using three-phase current supply, synchronous converters are mostly used in America and England and motor-generators on the Continent.

[1] Most of the above facts were taken from the *Mining Journal*.
[2] *Teknisk Tidskrift*, Aug., 1917; *Chem. Met. Eng.*, Dec. 15, 1918.

Recent tests on the melting point of the electrolyte used have shown:

| | |
|---|---|
| Cryolite | 1000° C. |
| Cryolite + 3 per cent. alumina | 974° C. |
| Cryolite + 4 per cent. alumina | 960° C. |
| Cryolite + 5 per cent. alumina | 915° C. |
| Cryolite + 6 per cent. alumina | 960° C. |
| Cryolite + 7 per cent. alumina | 982° C. |
| Cryolite + 8 per cent. alumina | 992° C. |
| Cryolite + 9 per cent. alumina | 980° C. |
| Cryolite + 15 per cent. alumina | 994° C. |
| Cryolite + 20 per cent. alumina | 1015° C. |

Between 8 and 9 per cent. alumina there is an apparent break in the curve, probably caused by a change in the composition in the bath. If $AlF_3$ is added the melting point will drop still further. With 20 to 30 per cent. $Al_2O_3$, the bath becomes thicker and $Al_2O_3$ separates out on the bottom. If the temperature of the bath is too high, $Al_4C_3$ may form, in yellow hexagonal plates.

If run between 800 and 1000° C., some $CO_2$ is formed at the anodes, 5 to 10 and even 20 parts of $CO_2$ to 100 parts of CO.

Some $SiF_4$ may be evolved from the bath, blackening the copper bus-bars, and whitening the glass of the shop.

Twenty-five kw.-hr. may produce 1 kg. of aluminium, but 33 to 35 kw.-hr. is the more frequent value. The electrode consumption is 0.7 to 0.9 kg. per kilogram of aluminium.

The cost per pound may be itemized as follows:

| | Cents. |
|---|---|
| 16 kw.-hr. @ 0.14 cts | 2.24 |
| 2 lb. $Al_2O_3$ @ 2.27 cts | 4.54 |
| 0.8 lb. electrodes @ 3.18 cts | 2.54 |
| 0.12 lb. cryolite @ 3.64 cts | 0.44 |
| 0.05 lb. Al fluoride @ 4.54 cts | 0.27 |
| 0.15 working hours @ 5.12 cts | 1.38 |
| Miscellaneous | 1.38 |
| | 12.79 |

G. Guilini proposes to reduce $Al_2O_3$ by C in a vacuum,[1] thus removing the CO gas as quickly as it is formed and preventing it from re-oxidizing the aluminium. Curiously enough, he states that the aluminium is also produced as vapor, and is therefore quickly removed by the high vacuum from the neighborhood of the carbon reducing agent, and thus the formation of aluminium carbide is prevented. He must use a wonderfully discriminating vacuum.

P. R. Hershman of Chicago reduces alumina by carbides.[2] The mixture is pressed into the form of a resistor, with some metallic filings or chips included to keep the conductivity, and heated by an electric current in an atmosphere of hydrogen or hydrocarbons. The resulting metal "may be tapped shortly after its formation." Doubtless it can, if it ever appears; yet we have forgotten—there was finely divided aluminium put into the mix.

[1] U. S. Patent No. 1257995, Mar. 5, 1918.
[2] U. S. Patent No. 1273220, July 23, 1918.

WORKING

*Purification.*—The *Chemical Trade Journal*[1] records experiments by by F. Milius of the Berlin Reichanstalt, to the effect that silicon can be removed from aluminium by fusing it under sodium nitrate. No further details are given; the statement needs confirmation. The further statements are made that when aluminium containing 16 per cent. of iron was chilled and treated with dilute hydrochloric acid the iron was reduced to 0.1 per cent., but only 20 per cent. of the aluminium was recovered. A more promising idea is that aluminium surfaces which had taken up iron during manufacture were successfully freed from iron by use of dilute hydrochloric acid.

*Hardening.*—The annual statement is made that some method of hardening the pure metal has been found. This time, according to the *Salt Lake Mining Review* of July 30, 1918, it is Tilman White, a millwright of Oakland, Calif., who has succeeded by special treatment in raising the tensile strength to 40,000 lb. per square inch. Whether this is by heat treatment or by alloying with a hardening metal is not stated.

*Annealing.*—R. J. Anderson describes[2] interesting results obtained on cold-rolled aluminium sheets by exceedingly brief exposures to annealing temperatures. The usual practice is to anneal 18 to 30 hr. at 375° C., reducing the "Shore scleroscope" hardness number from 13–15 down to 4–5. In this operation, however, the sheets are often over-annealed, microscopic investigation showing unusually coarse grain structure, and the metal is liable to go to pieces in the drawing press. Annealing of this metal (which had been reduced 72 per cent. by cold rolling) for 2 hr. at 400° C. entirely removed the difficulty. Annealing for 3 min. only, at various temperatures, showed the following range of hardness tests:

| Time, Minutes. | Temperature, Deg. C. | Shore Scleroscope Number. | Erichson Test, Indentation, Mm. |
|---|---|---|---|
| 3 | 200 | 15.0 | 7.90 |
| 3 | 250 | 14.0 | 8.60 |
| 3 | 300 | 14.0 | 8.75 |
| 3 | 350 | 13.0 | 8.93 |
| 3 | 400 | 12.0 | 9.09 |
| 3 | 450 | 9.0 | 9.52 |
| 3 | 475 | 5.5 | 10.05 |
| 3 | 490 | 5.5 | 10.70 |
| 3 | 500 | 4.5 | 10.64 |
| 3 | 550 | 4.5 | 11.00 |
| 3 | 600 | 4.5 | 11.10 |

These tests show the plates made as soft as it is possible to make them by 3 min. annealing at 500° C.; 8 min. at 450° C. produced a similar effect. All the blanks treated at these temperatures worked properly in the draw-press. It is thus proved that very great saving in time and expense is possible by annealing at higher temperatures than are now practised.

[1] **64,** 165 (1919). [2] *Iron Age*, July 18, 1918.

L. H. Whitney[1] heats the articles quickly to a temperature above 370° C., but not over 450°, and keeps them there 2½ to 3 hr., then cools them quickly, as by quenching in water or blowing air on them. It is stated that this treatment converts the graphitoidal silicon present as an impurity into uniformly dissolved silicon, and gives maximum annealing effects.

*Melting Scrap.*—Charles Vickers gives some interesting information about the reclaiming of scrap aluminium, which became an important item during the war when the ingot metal was so scarce.[2] Loose clippings should be briquetted into dense lumps, in order to get a satisfactory weight of metal into the furnace. Wire in the form of cable can be cut into suitable lengths, but should not be allowed to untwist. Loose wire in short lengths costs considerable to re-melt, with a loss of some 7 per cent. Zinc chloride (?) is recommended as flux to separate oxide from the metal; with a high-zinc alloy, salammoniac.

## Alloys

Paul D. Merica[3] publishes a valuable compilation of the literature of aluminum and its light alloys.

Circular No. 76 of the Bureau of Standards[4] contains 120 pages on "Aluminum and its Light Alloys," describing their physical and chemical properties. The compilation is fairly well done.

*Zeppelin Alloy.*—A piece of alloy taken from a smashed Zeppelin in England contained 91.92 per cent. Al, 4.13 Cu, 3.27 Fe and 0.65 Si. The only remarkable constituent is the iron, which is much higher than has been used before in such alloys. Its tensile strength was 40,000 lb. per square inch.

*Ferro-aluminium.*—J. W. Richards, in the course of an address on ferro-alloys, at the Fourth National Exposition of Chemical Industries, called attention to the possibility of making 50-per cent. ferro-aluminium in electric furnaces similar to those now used for 50-per cent. ferrosilicon. He estimates the cost of such alloy at $100 per ton, furnishing the contained aluminium at 10 cts. per lb. instead of the 30 cts. which the steel industry now pays for No. 2 grade metal. Such alloy could be made directly from crude bauxite and iron ore, or from the red bauxite rich in iron found abundantly in southern France and Austria.

*Aluminium Bronze.*—W. M. Corse gives the following aperçu of the physical properties of bronze containing 10 per cent. aluminium and 1 per cent. iron:[5]

[1] U. S. Patent No. 1273706; July 23, 1918.
[2] *Met. Market Rept.*, Aug. 12, 1918.
[3] *Chem. Met. Eng.*, **19**, 135, 200, 329, 587 (1918).
[4] Washington, Apr. 21, 1919; price, 20 cents.
[5] *Bull. Am. Inst. Min. Eng.*, **144**, 1738 (1918); *Trans.*, **60**, 171.

| | |
|---|---|
| Ultimate tensile strength, lb. per sq. in. | 65,000–80,000 |
| Ultimate tensile strength, kg. per sq. cm. | 45.5–56.0 |
| Yield point, lb. per sq. in. | 23,000–28,000 |
| Yield point, kg. per sq. cm. | 16.1–19.6 |
| Elongation in 2 in. (5 cm.), per cent. | 20–30 |
| Reduction to area, per cent. | 21–29 |
| Specific gravity at 20° C. | 7.5 |
| Brinell hardness number (500 kg. load for 30 sec.) | 92–100 |
| Pattern maker's allowance for shrinkage, in. per ft. | 0.22 |
| Pattern maker's allowance for shrinkage, percentage | 1.8 |
| Weight per cu. in., lb. | 0.27 |
| Compression, elastic limit, lb. per sq. in. | 19,000 |
| Compression, elastic limit, kg. per sq. cm. | 13.3 |
| Coefficient of friction | 0.0025 |
| Modulus of elasticity, lb. per sq. in. | 15,000,000–18,000,000 |
| Modulus of elasticity, kg. per sq. cm. | 10,500–12,600 |
| Resistance to impact, Fremont notched-bar test (fractured section 7 by 10 mm.) kg.-meters | 7–10 |
| Endurance of alternating impact, Landgraf-Turner or Arnold test, alternations | 3,500–5,500 |
| Resistance to shear by impact, McAdam machine, ft.-lb. | 750–850 |
| Resistance to shear by impact, McAdam machine, kg.-m. | 104–118 |

*Giesserei Zeitung* states[1] that with bronze over 7 per cent. aluminium special heat treatment improves the properties greatly. With 10 per cent. aluminium, heated to 800° C. and quenched, it shows hardness 100 to 200 Brinell, according to its cross-sectional area. Bronze thus hardened is a good bearing metal for speeds up to 20,000 r.p.m. The following table gives the mechanical properties attained, the special heat treatment consisting in quenching from temperatures below 800° C.

| | Limit of Elasticity, Kg. per Sq. Mm. | Tensile Strength, Kg. per Sq. Mm. | Extension, Per Cent. | Contraction, Per Cent. | Hardness, Brinell. |
|---|---|---|---|---|---|
| Original alloy (cast) | 9.6 | 59.80 | 19.5 | 23.7 | 100 |
| Original alloy (quenched) | 19.8 | 73.64 | 1.0 | 0.8 | 262 |
| Special heat treatment | 27.7–19.2 | 67.69–64.14 | 5.5–14.0 | 9.1–18.5 | 158–140 |

H. Rix and H. Whitaker read a paper[2] before the British Institute of Metals describing Die Casting of Aluminium Bronze. This has been attempted for many years, but has only lately been successful. The alloy used contains 7 to 10 per cent. aluminium and 1 to 4 per cent. iron. The function of this rather larger proportion of iron is to form a skeleton or matrix of the high-melting-point compound $FeAl_3$, which solidifies first and thus reduces the shrinkage and produces a fine grain. The iron also increases the yield point and ultimate strength, so that the casting does not pull itself apart while cooling in the die. Iron should be added as pure iron chips; no silicon at all should be put into the alloy. The dies should be of chill-cast, close-grained, gray cast iron, as hard as can be machined. If low in combined carbon it will not "grow" during use, and will stand five to seven thousand casts. No facing is used on the die. The core-plugs are chromium-tungsten steel,

[1] *Metal Ind.*, April, 1919.

[2] *Chem. Met. Eng.*, Feb. 1, 1919.

and are dipped in a graphite wash as soon as withdrawn. Cores must be removed at just the right time, to avoid rupture of the metal around them. A casting made in a 1-in. chill had the following physical properties:

| | |
|---|---|
| Diameter of test piece | 0.564 in. (14.1 mm.) |
| Yield point | 29,400 lb. per sq. in. (20.6 kg. per sq. mm.) |
| Ultimate tensile strength | 71,000 lb. per sq. in. (49.7 kg. per sq. mm.) |
| Elongation in 2 in. (5 cm.) | 24.0 per cent. |
| Reduction of area | 21.8 per cent. |

The authors point out that a proper scientific study of the problem of die casting any alloy requires an investigation of its coefficient of expansion at different temperatures, fluid and solid; its thermal conductivity; its specific heat; its mechanical properties at high temperatures; its mass, volume, and surface area when cast; its metallography; its pressure on the die; and its fluidity—all of which is very true and pertinent